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Building a Common Ground on the Clinical Case: Design, Implementation and Evaluation of an Information Model for a Handover EHR

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Abstract. Handovers need a common ground on the clinical cases between the members of the successive shifts to establish continuity of care. Conventional electronic patient record systems (EHR) proved to be only insufficiently suitable for supporting the grounding process. Against this background we proposed a basic concept for a handover EHR that extends general EHRs in particular openEHR based systems. The resulting handover information model was implemented in a database and evaluated based on 120 clinical cases. The information items of these cases could be mapped successfully to the model, however, the new class "anticipatory guidance" needed to be introduced. The evaluation also demonstrated the importance of highly aggregated information on the clinical case, opinions and meta-information such as the relevance of an item during handovers. Based on these findings, in particular the handover database, handover EHR applications are currently developed to support the grounding process.

Keywords. Handover, electronic health record, communication, common ground

Introduction

Close cooperation among health professionals across professions and shifts is an essential prerequisite for ensuring continuity of care. Cooperation heavily depends on exchanging patient information in the context of current care processes, such as communication accompanying the processes as well as communication at specific exchange nodes, i.e. handovers or handoffs [1], ward rounds [2] and case conferences [3]. Communication not only transfers information but establishes a shared information and knowledge space, the so called common ground [4]. Weir et al. distinguished between establishing a common ground via communication and relying on existing shared situation models that result from previous experience and persist as cognitive models [5]. Handovers, ward rounds and case conferences belong to the "moments of common ground", where the next steps along the care trajectory are planned and communicated [6]. Factors that facilitate building a common ground are coordination

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and documentation of goals of care [3,7], care summaries and interrelated individual pieces of information that are put into the health context of the patient [5]. All these factors aim at creating a coherent picture of the clinical case that is shared among the care workers [3,5,7]. Given an ongoing diagnostic and treatment process this picture consists of objective retrospective information as well as of subjective prospective information that guides the clinicians along the care path.

Among the collaborative clinical scenarios handovers are most crucial in ensuring continuity of care over time. In the following we will thus concentrate on handovers.

Most of today's electronic health record systems do not support this scenario in a satisfying manner because they only serve as data repositories for the documentation of objective facts, i.e. what has been found and done. Documentation systems do not primarily care for directing the information [7,8] or for fulfilling the communication needs [7,5]. These EHR systems that had been used in handover situations were mostly employed to provide recent facts about the patient. These fact sheets were then printed and distributed on paper to the participants of the handover meeting [9].

The overall goal of this project is to design, implement and evaluate an augmented EHR that is suitable for supporting care scenarios with a high demand for communication, in particular for patient handovers (handover EHR). This EHR has to be designed to help clinicians build a cognitive model of the clinical case and share their understanding with their colleagues (common ground). The first aim of this paper is thus to develop and implement a handover information model and a concept for the access to handover specific information. The second aim is to empirically evaluate the model for suitability and completeness in the two areas: a) verified retrospective patient information and b) anticipatory guidance (e.g. warnings, recommendations and notifications).

1. Materials and Methods

1.1 Handover information model

In order for the handover information model and the access concept to be developed basic constraints have to be defined. These constraints were expressed in the form of a basic concept of the handover EHR. The concept was deduced from the recommendations of a comprehensive systematic literature review on handovers [10] that focused on common grounding and the role of the electronic patient record system to avoid errors, systematize the handover content and meet the user's cognitive needs. The review highlighted the need for both retrospective and prospective information, for objective verified as well as for subjective information and for facts in combination with anticipatory guidance. The findings of the review emphasized the role of communication in handovers and showed that documentation style of presenting the information, i.e. lists or forms, was insufficient. Handovers were meant to provide the "full story" of the clinical case [11] in a highly succinct manner.

This basic concept served as foundation for a detailed handover information model. Where possible this model relied on existing specifications in particular on openEHR using the Clinical Knowledge Manager as library of openEHR archetypes [12] and the National Health Service clinical models archetype repository [13]. The resulting handover information model was written in UML as class diagrams.

1.2 Translation of the handover information model into a database

The object oriented information model was translated into a relational data base scheme using Hybernate. The handover database was implemented in MySQL utilizing an InnoDB storage subsystem. An application for entering clinical data into the database, updating and deleting them was developed. A role based access manager was designed that realized the communication concept included into the basic concept of the handover EHR. The access manager was then integrated into the handover database system.

1.3 Evaluation of the handover information model

One hundred twenty clinical cases of Klinikum Osnabrück, a 650 beds community hospital, served as material for evaluating the handover information model. The 120 cases were split into two groups of equal size, one group for which verified retrospective information was available through paper-based patient records and the other group of cases that were currently treated in the hospital and for which handovers could be observed to identify typical handover information such as anticipatory guidance. Sixty paper records were drawn at random from the population of 9308 cases of the hospital in the first quarter of 2012. These 60 cases originated from all clinical departments. The records were anonymised and medical and nursing information was extracted by a clinical expert (DF). In addition, five nursing handover sessions including 90 patient handovers were observed by the same clinical expert and the medical and nursing information of these patients was recorded. After deleting duplicate cases 60 cases were drawn at random from the remaining 84 cases. The handovers took place on a surgical, a cardiological and an early neuro-rehabilitation ward. The document analysis and the handover observations were performed in accordance with the ethical regulations of the hospital and after approval of the data security officer and the executive director of the hospital.

2. Results

2.1 Basic concept of the handover EHR

The underlying concept of the handover EHR (figure 1) is the idea of an electronic EHR based tool that is used in face-to-face meetings and does not substitute direct personal communication. It embraces the full spectrum of the documentation-communication space and aims at supporting the out-going team to concisely present all pertinent information and at helping the in-coming team to capture the essence of the clinical case in a relatively short time. Presenting and capturing the information strongly require cognitive efforts of the individuals involved, which will have to be facilitated by the handover EHR. The overall architecture of the handover EHR is structured in four layers: the persistent layer, the semi-persistent layer, the functional layer and the visualization layer. The persistent layer consists of the data repository, typically the electronic patient record, which contains verified objective clinical information of events and results that happened in the past (retrospective information). This layer represents the documentation end of the documentation-communication continuum. It is supplemented by the semi-persistent layer, which makes provisions for

subjective information (opinions, warnings, recommendations), which are usually of volatile nature. This type of information is personalized and directed from the out-going to the in-coming team and thus needs special protection. The functional layer includes all functions that handle or make use of the information. The visualization layer, finally, ensures an appropriate method of presenting the information in terms of information display, manipulation and transport. All four layers, particularly the visualization layer, ensure developing a common ground among the communication partners.

2.2 The handover information model

The handover information model (figure 2) corresponds to the persistent and semi-persistent layer. It is composed of the clinical and the administrative case and specifies the clinical case in detail. Like any health information model the handover information model refers to all different types of health information of a patient. However, in contrast to models that are underlying electronic records (documentation!) the handover information model contains representations of meta information, e.g. for uncertainty, relevance, progress of a problem (acute or chronical or intermittent), status of a procedure or a problem and includes opinions.

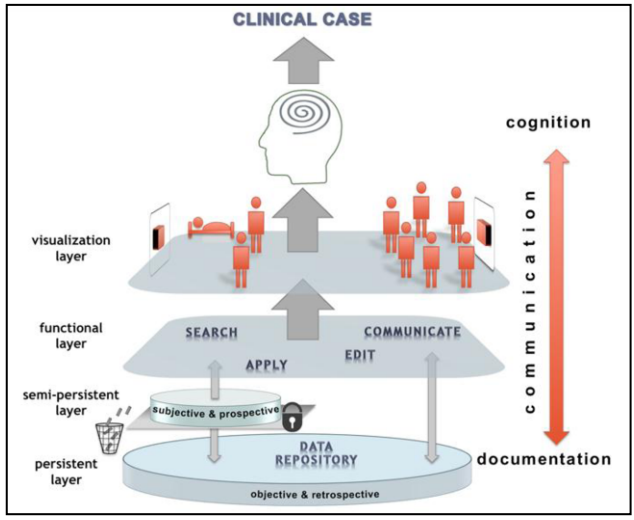

Figure 1. Basic concept of the handover HER

Among existing information models the openEHR architecture [14] came closest to meeting the requirements of the basic concept of a handover EHR. In accordance with openEHR the clinical case, the center piece of our information model, thus embraces the classes *problem*, *procedure*, *medication*, *opinion* und *goal*, which are interrelated and which all include the option to express the relevance of the respective phenomenon.

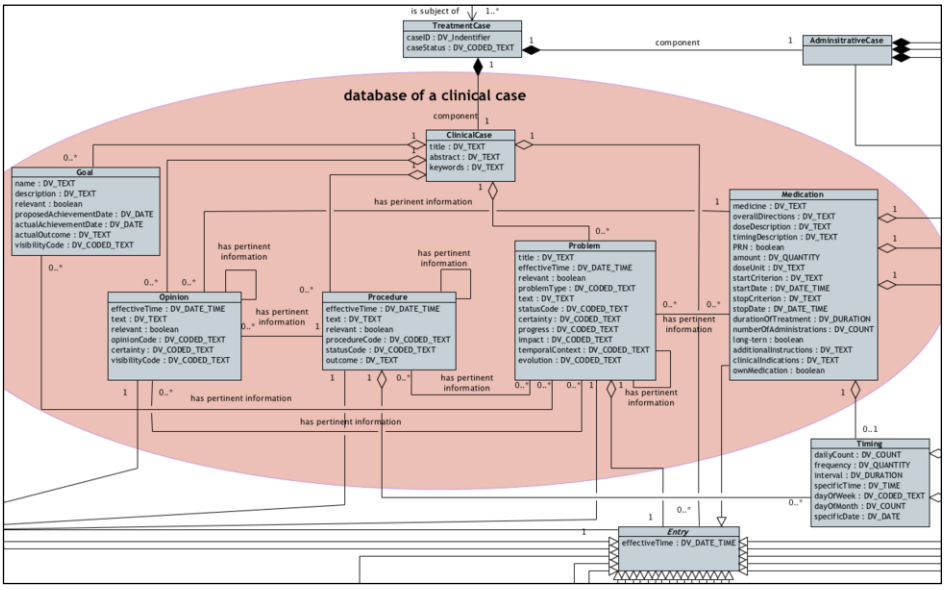

Figure 2. Information model of the handoverEHR – details

Problems can be phrased as narrative text or as clinical entries such as *patient history*, *assessments and scales*, *wound information*, *lab values*, *vital signs*, *fluid balance and nutritional information* [12]. Contextual information of a problem can be provided via the archetype *problem context qualifier*. *Procedures* and *medication* are both related to *problems* and represent clinical consequences of a problem. *Opinions,* a class that contains free text, may refer to *problems*, *procedures or medication*. *Goals*, another container of narrative text, may be additionally used to denote a planned date, at which the goal should be attained, and clinical outcomes related to that goal. *Goals* are interrelated with *problems*.

Complementary to the openEHR architecture, which mentions opinions but does not provide an opinion archetype, the opinion class was specified and the relevance attribute added to all classes. In order to allow narrative summaries to be included we introduced the *clinical case* class.

2.3 Access control to handover specific information

Subjective, transient or (still) unverified information has to be actively made accessible to others by the author of the information. The *opinion* and *goal* classes therefore possess a *visibility indicator* for hiding the information from persons not involved in the handover communication. The *visibility indicator* (figure 3) embraces the graded categories *only the author, specific persons, 24 hours for all authorized individuals* and *all authorized individuals. Only the author* is a category not used in communication but for personal notes, which are made e.g. during the handover meeting or during caring activities. *Only the author* labeled information may receive the *forget* status. *Specific person* denotes a member of the out-going and the incoming shift. *24 hours for all authorized individuals* opens the accessibility of information not only to the next shift but also to the next but one and to other professional groups not attending the handover meeting.

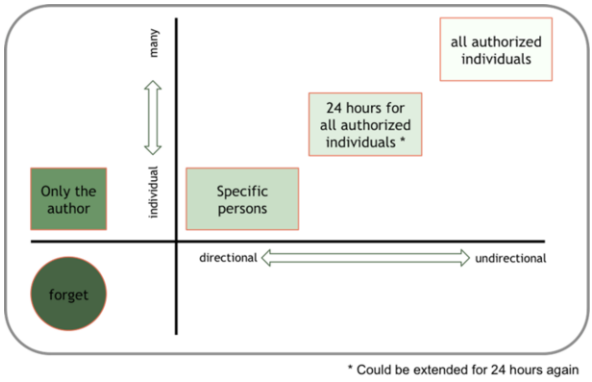

Figure 3. Levels of visibility

2.4 Evaluation of the information model

Assigning medical and nursing information items that were found in the patient records and in the patient handovers to the classes of the information model resulted in a good match (table 1):

Table 1. Average number of information items per clinical case

	problems	***procedures***	***goals***	***opinions***	***medications***
documentation (n=60)	5,29	2,88	0,10	**0,14**	0,56
handover (n=60)	3,02	1,60	0,00	**0,55**	0,50

However, there was a remaining number of 14 items in patient records and 97 in handovers that could not be allocated to the existing classes. Examples were *"son in law will call the doctors to give his consent to the surgery" and "thorax CT postponed because creatinine value is too high"*. All these items described notifications highly relevant to practical care management also in the sense of anticipatory guidance for the next shift. We therefore suggest to build a new class that encompasses the openEHR opinion class and is geared towards a central requirement of handovers, i.e. *anticpatory guidance*. The relevance of information items in records could be deduced only indirectly via the rank in the list, in handovers the relevance was directly expressed by gestures, the pitch of the voice and by the preselection of items in the pre-handover phase. Patient summary information, which was represented by the *clinical case* class, was found only in medical or nursing summaries added to the record at patient discharge. In handovers, such summaries were given to the in-coming shift if the patient or a team member was new.

3. Discussion

Documentation, communication and decision-making are essential cognitive activities during pre-handover, handover and post-handover [15]. Against this background, the handover EHR needs specific levels and objects of information. openEHR archetypes

yield a clinically sound, expert based "maximum data set" [16], for general purpose EHRs from which an initial information model for the handover EHR could be derived.

This initial model had to be supplemented in accordance with the basic handover EHR concept and had to incorporate the findings of the evaluation. The evaluation showed (i) that opinions, an essential element of handovers, were less often found in records than in face-to-face handovers, (ii) that the relevance of information was not directly coded in patient records, (iii) that handover information was highly aggregated in the sense of a free text clinical summary and less detailed than information in patient records and (iv) anticipatory guidance information needed to be considered. These findings strongly hint at the fact that general-purpose EHRs only partly cover the information typically communicated in handovers and are necessary to develop a cognitive representation of the clinical case. This highlights the need for a specific handover EHR that allows a common information ground between teams of consecutive shifts to be achieved. During handover, detailed and highly elaborated information objects only play a subordinate role. More important are the relationship between information objects, the inclusion of subjective information to provide anticipatory guidance and to label the relevance of information objects and finally the guided flow of information between the actors..

Our approach does not contradict common methods for structuring handover information [11], in particular SBAR (situation, background, assessment, recommendations), but provides a subjacent model whose components can be mapped to SBAR. *Situation* embraces the AdministrativeCase class, Background embraces the Problem, Medication and Procedure classes – and if required the Goal class. Information on *Assessments* and *Recommendations* can be taken from the Procedure class and the Anticipatory_Guidance class.

Although SBAR is one of the most well known concepts for structuring handovers it is not entirely uncontroversial. Joffe and colleagues found that SBAR forms with too many details led to reduced compliance of the information giver and thus to the risk of erroneous information [17]. The findings of our evaluation support these results. Handover information was typically less rich and more consolidated with fewer details compared to items of the patient record. Bearing in mind the goal of handovers, e.g. building a common ground in a relatively short time, less can be more indeed.

4. Conclusion

The handover information model proved to be a solid foundation for a handover EHR as an extension of existing EHRs. Pursuant to the basic handover concept and building on the handover information database, EHR applications on the functional layer and their visualization are currently developed to support the grounding process. Our developments contribute to the notion of handovers as a cognitively highly demanding process to achieve continuity of care.

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